

Maintainability: Theory and Practice

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Introduction

- Definition
- Theory
- Metrics
- Practice
- New Directions

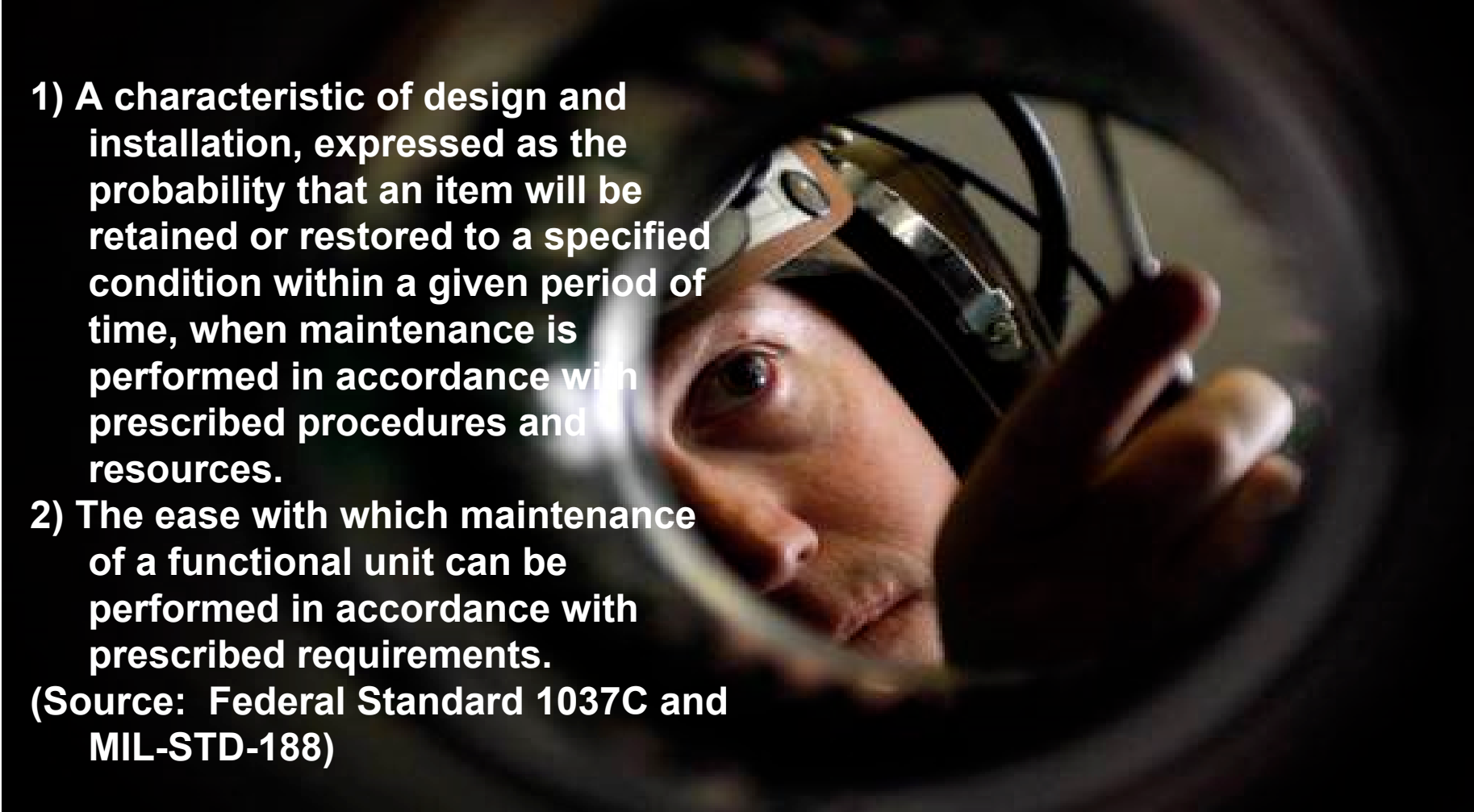
Definition

“The relative ease and economy of time and resources with which an item can be retained in or restored to a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair. In this context, it is a function of design.”



Photo: Courtesy of DoD DefenseLink

Definition

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- 1) A characteristic of design and installation, expressed as the probability that an item will be retained or restored to a specified condition within a given period of time, when maintenance is performed in accordance with prescribed procedures and resources.
 - 2) The ease with which maintenance of a functional unit can be performed in accordance with prescribed requirements.

(Source: Federal Standard 1037C and MIL-STD-188)

Definition

Reliability:

The ability of a system or component to perform its required functions under stated conditions for a specified period of time.



Photo: Courtesy of DoD DefenseLink

Definitions

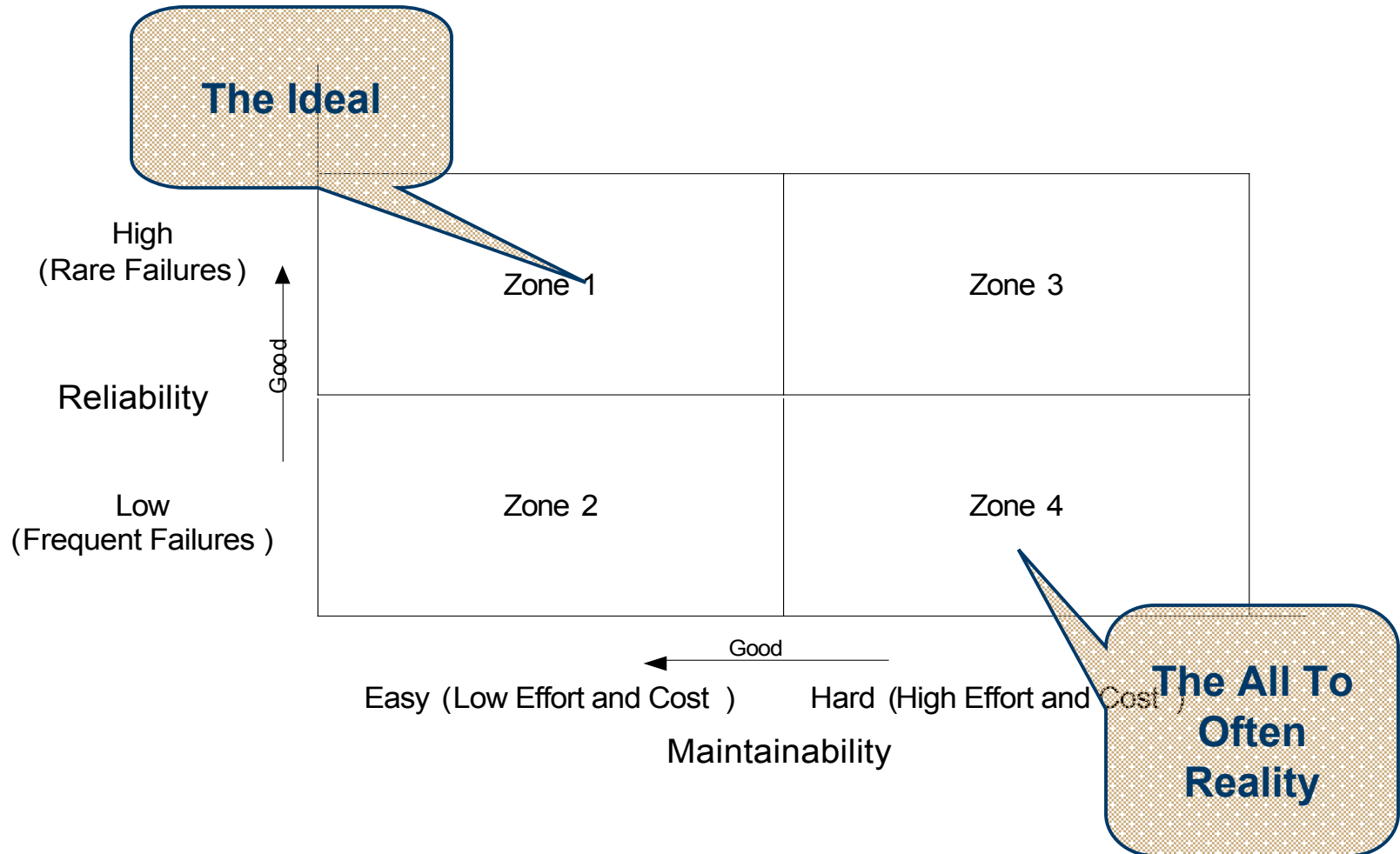
Mean Time To Repair

The arithmetic mean of the time required for maintenance actions divided by the number of actions



Photo: Courtesy of DoD DefenseLink

Reliability and Maintainability



Theory

- Use and Development of Theory in Maintainability centers around the use of statistics and sampling theory to *predict* aspects of 'ease and economy of resources':
 - Mean Time to Repair
 - Availability
- Mainly used as basis for estimation during system design and development

Metrics

Measure	Description
Mean Time to Repair (MTTR)	The arithmetic average of the maintenance cycle times for the individual maintenance actions of a system (excludes preventive maintenance)
Mean Preventive Maintenance Time	The arithmetic average of the maintenance cycle times for the individual preventive maintenance actions of a system (inspection, calibration, planned replacement, etc)
Median Active Corrective Maintenance Time	The value of corrective maintenance time that divides all downtime values for corrective maintenance so that 50% are equal or greater than the median
Mean Active Maintenance Time	The mean or average <i>elapsed time needed to perform maintenance (both preventive and corrective) excluding logistic and administrative delays</i>
Maximum Active Corrective Maintenance Time	That value of downtime below which one can expect a specified percent of all corrective maintenance to be completed. Must be stated at a given percentile, usually 90 or 95 th , primarily related to a lognormal distribution.
Mean Time to Restore System	For highly redundant systems, this is the time need to switch to a redundant backup unit
Mean Down Time	The mean or average time that a system is not operational due to repair or preventive maintenance. This includes logistics and administrative delays.
Maintenance Labor Hours per Hour/Cycle/Action/Month	A measure of labor hours expended, based on operating or calendar time, maintenance actions or operating cycles

Source: The RAC Maintainability Toolkit, pg 5

Metrics

- **Maintenance Information Systems** generally record actions by organizations
- **Maintainability Metrics** are lagging measures from operational databases
 - Often report Symptoms vs Causes
 - Accuracy is Generally Low
 - Completeness (more than 1 Discrepancy?)
- **Metrics** are used to drive system changes, but improvement comes hard
 - Diffuse responsibilities and actions
 - Platforms develop age related degradation

New Directions

- **Maintainability and Reliability are growing in importance to initial design**
 - But developing basic design principles for maintainability is still somewhat elusive
 - Adapting “Lean” and “Theory of Constraints” methods has improved execution of legacy systems
- **Owner/Operators are driving responsibility for improvement back to OEMs through innovative support methods:**
 - Performance Based Logistics
 - Condition Based Maintenance

New Directions

- **Technology will be incorporated to improve:**
 - **Fault Identification and Fault Tolerance**
 - **Technical Information and Training**
 - **‘Sense and Respond’ Support Actions**



